ZANGERLE

The Steeping of Barley

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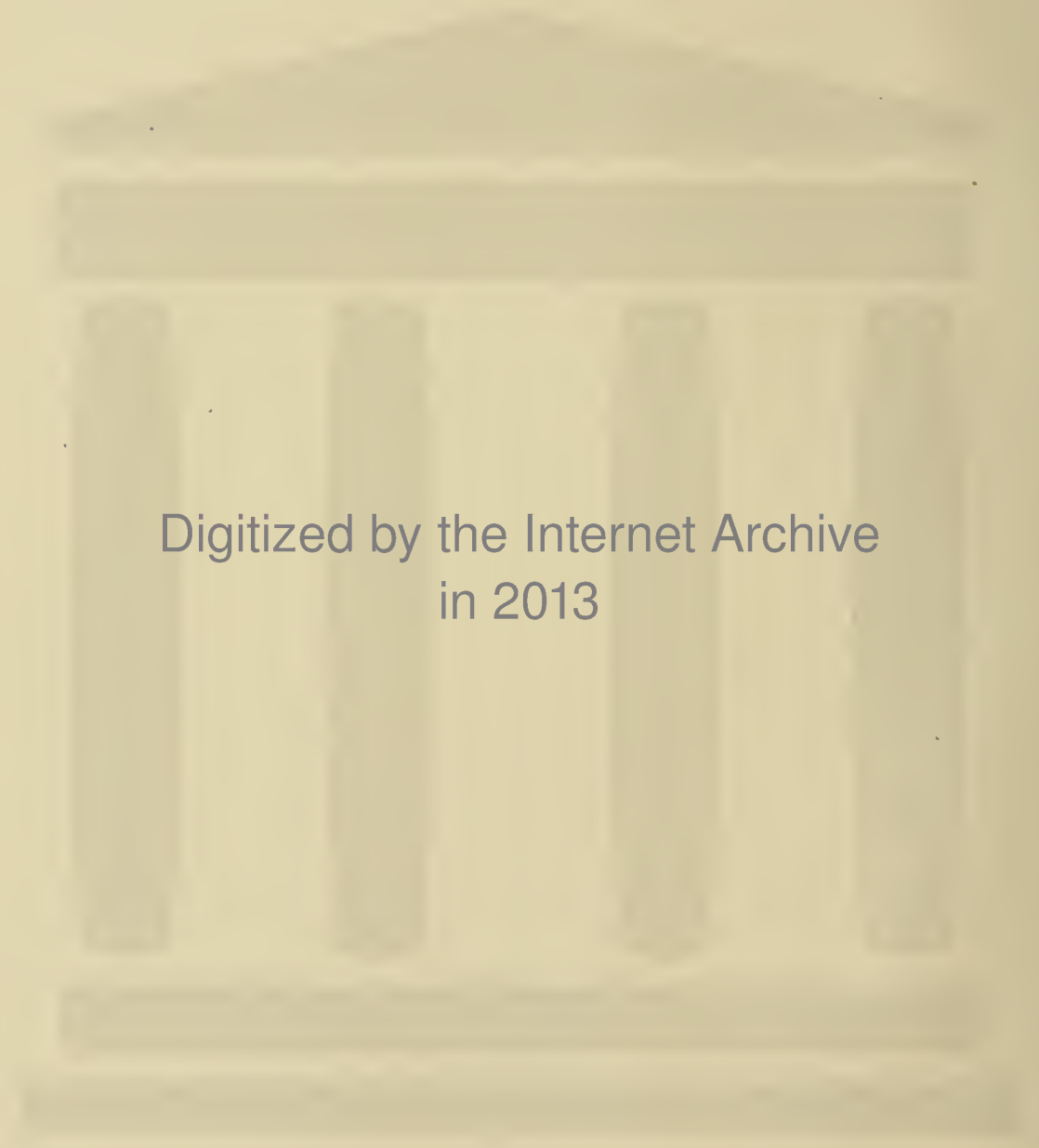

THE STEEPING OF BARLEY

A Comparison of the Effects of the Use of Hard and Soft Waters

BY

ARTHUR NORMAN ZANGERLE

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

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May 27th, 1903

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Arthur Norman Langworthy

ENTITLED The Steeping of Barley

A comparison of the use of hard and soft waters.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science

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Received May 27.

INTRODUCTION.

The object of the following thesis is to either verify or disprove the popular supposition, that in the steeping process, a soft water extracts more substances which are which are of value to the brewer, than a hard water does. The popular idea among brewers seems to lean towards the fact, that a soft water has a greater dissolving power than a hard one, for the reason, that it does not hold as much mineral matter in solution, and is therefore less saturated as regards all kinds of substances that are contained in barley. On the other hand a hard water may contain salts such as sodium chloride, which materially increases its solubility for certain substances as for instance for albuminoids.

For the purpose of making experiments to determine the amount of substance going into solution, the malt-house operations during the steeping and sprouting process were adhered to as much as was possible under the circumstances. Previous to entering the steep-tank the barley is washed, and this may be accomplished in several ways. One method employs an injector-shaped vessel, where the grain and water are allowed simultaneously to enter, being there thoroughly mixed and the grain washed, whereupon both pass over a sieve, where the grain is intercepted and transferred to the steep-tank. I simply put the grain in a sieve and shook it in a large evaporating-dish filled with the water I was to use for steeping. The steep tank in which the barley is soaked or steeped, consists now almost

universally of cylindrical iron hoppers, with conical bottoms. Attached to the point of the cone is a steep-tank valve which is usually supplied with two opening devices, one for drainig off the water and another for discharging the barley. Some steep-tanks are supplied with an aerating device for injecting air into the steeping grain. To imitate these tanks as closely as possible thereby equalizing the conditions of steeping, I used percolators with conical bottoms, with the outlet at the bottom. To keep the grain from running down into the tube, I perforated a cork in such a manner that water could flow through, but that the barley grains could not.

Steeping is the process of soaking the barley with water, and is performed by immersing the grain in the steep tank for a period of time and under certain conditions. It aims to impart to the grain sufficient moisture to start and carry on germination, and also to dissolve from the husk the coloring matter and other extractible substances which otherwise would give the malt a raw taste.

Different varieties of barley will absorb different amounts of water in a given time. The period of steeping depends upon:-

1. The character of the water, whether soft or hard;

2. The temperature of the water;

3. The character of the barley, whether the hull is thick or thin, whether the endosperm is mealy or glossy, whether the diameter of the kernel is great or small;

4. The age of the barley..

There has been some discussion as to the proper character of

the steep-water and as aforesaid the popular idea seems to be that a soft water dissolves from the barley too much soluble albuminoids and mineral substances which the yeast requires for food. The best water for steeping as recommended by Wahl and Henins is a medium-hard, pure spring or shallow-well water. My purpose has been to use some barley and to steep it in both hard and soft waters using pure distilled water to water containing carbonates in solution, especially prepared by running CO_2 into the water forming the soluble bicarbonates, also water containing large percentages of certain salts, which both aid and hinder solution.

The water was run into the percolators containing the barley, allowed to stand for about twelve hours, when it was run off below and a fresh quantity added, sufficient in amount to keek it thoroughly soaked. The steep-water was collected in a two-liter flask and kept in a cool place to prevent fermentation.

When the barley was sufficiently steeped, which was determined by any of the following signs, it was spread out on the bottom of a thermostat and germination allowed to begin.

Signs of Sufficient Steeping:-

1. When cutting through a grain, the contents should appear completely and uniformly wetted, with the exception of a minute speck in the center of the endosperm;

2. When taken by the ends between the thumb and index finger, and pressed, the kernel should not prick the skin;

3. The kernel should be elastic enough to be bent over the finger nail without breaking;

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When the barley was sufficiently steeped, which was determined by any of the following signs, it was spread out on the bottom of a thermostat and germination allowed to begin.

Signs of Sufficient Steeping:

1. When cutting through a grain, the contents should appear completely and uniformly wetted, with the exception of a minute speck in the center of the endosperm.

2. When taken by the ends between the thumb and index finger, and pressed, the kernel should not prick the skin.

3. The kernel should be elastic enough to be bent over the finger nail without breaking.

4. At the end where the radicle is located the hull should appear to be open;

5. Upon biting gently into a kernel, the endosperm should move to both sides without breaking or cracking;

6. A sample of barley taken from the steep-tank should show an increase in weight of about 45%.

Of these indications numbers one and six are most reliable.

The temperature of the water during steeping should not exceed 55 degrees F.(10 degrees R. or 12 1/2 degrees C.)otherwise mouldy growth will be encouraged. The softer the water, the higher its temperature, the smaller the diameter of the grain, the thinner the husk, the more mealy and the younger the barley,---the less time is required for steeping.

Barley should never be oversteeped or be allowed to become sodden, otherwise its vitality may be impaired. Sprinkling on the floor can be resorted to if there is not enough moisture in the grain, but where there is too much it cannot be removed. It is safer to understeep than the opposite. After steeping the barley I spread it out upon the first trial upon the bottom of a thermostat but later I found that large shallow pans(candy-trays)were just about as good, and the barley was easier to handle. Of course the barley was germinated according to the old traditional method, because nowadays malting is done mosaly by machinery, and may therefore be called mechanical malting.

The chief points to be observed in carrying on germination are:-

1. To provide sufficient moisture;

2. To maintain suitable temperatures;

3. To aerate the grain;

4. To protect the growing grain from deleterious influences.

All these essential conditions should be so maintained as to operate on individual grains alike, thus producing uniformity of growth. Too high temperatures must be avoided since they promote the development of micro-organisms and facilitate uneven growth.

Growth should not be allowed to proceed too rapidly. The saving of time that might thus be effected is far more than made up for by by the fact that an unduly swift development of the acrospire and radicles will not allow of the requisite mellowness of the endosperm which is among the chief objects of germination.

The requisite moisture is provided in the first place by steeping. Subsequently at a more advanced stages of development, if the grain gets dry, sprinkling is resorted to. A fine-sprayed atomizer can be used for this purpose. The barley required generally about five days to sprout but according to my experience it often requires several days more. During germination the barley should be turned every now and then, and fresh air of about 12 1/2 degrees C. constantly admitted. In a large laboratory it is very difficult to observe this rule. If there is too much evaporation, if the growing barley becomes too dry, in which case the sprouts will be seen to wither, the barley should be sprinkled with water of approximately the same temperature as that of the heaps.

As soon as the malt has started to sprout it should be sprinkled and turned, after which the heap is set somewhat higher and the

temperature is allowed to rise to 68 degrees F.(16 degrees R. or 20 degrees C.)when it is broken and spread out thinner. If the If the heap is sprinkled before the sprouts appear, growth is apt to be checked as was the case with my first trial at germination. When the malt has grown sufficiently which can be told by the following signs, it is ready for drying.

Signs of Sufficient Growth:-

1. The acrospire should be developed to 3/4 of the length of the kernel;

2. The radicles should be developed to 1 1/2 times the length of the kernel;

3. Upon the kernel being pressed between the thumb and forefinger, the endosperm should be squeezed out and should have the consistency of mealy flower;

4. The radicles should cling together firmly so that in lifting a number of kernels between the forefingers, they should draw with them six to eight times the number of kernels held.

I dried the malt by simply putting it over a radiator and allowing it to dry in the pan. Analysis was then made of these different malts and the worts derived therefrom to note whether different steeping-waters produced any effect.

The first series of experiments were carried on with distilled water which was to represent a soft water, and the university tap-water, which is a medium-hard water containing about 400 parts per million total solids. To 250 grams of choice Dakota Barley in a percolator, arranged as previously described 250 cc. of the water

was added and allowed to soak the barley for approximately 12 hours, when it was drawn off and set aside in a vessel until the entire quantity was drawn off. In this manner, as can be seen from the following table, 250 grs. of barley were steeped in 850 cc. of water at 22 degrees C.for 64 hours. At the end of this time the barley was sufficiently steeped, which was determined by a number of signs stated previously in this thesis. The volume of steep-water was then measured and its analysis made immediately so as to protect against changes in its composition due to fermentation. The steeped barley was put into a thermostat and water added to aid in its growth. The malt was turned over from time to time to equalize the growth in the kernels, and after about five days the malt was dried, and the analysis made. The analysis of the maltfrom the first trial with distilled and with tap-water was not made. The results of the steeping of the barley, and the analysis of the steep water follow. These results show that there is practically no difference in the amount of the different substances extracted by a hard or a soft water.

TABLE NUMBER 1.

Steeping of Barley in #1 Tap-Water and #2 Distilled Water.

Date	Time	Amt. H_2O	Temp. H_2O	No. Hrs.	Remarks.
Nov. 3	4:00 p.m.	250 cc.	23 deg. C.	#######	Sample Dak. Barley
Nov. 4	8:00 a.m.	200 cc.	23 deg. C.	16 hrs.	250 grs. Barley in each percolator.
Nov. 4	5:00 p.m.	200 cc.	22 deg. C.	9 hrs.	Vol. #20 #1 650 cc.
Nov. 5	8:00 a.m.	200 cc.	22 deg. C.	15 hrs.	!! #2 is 653 cc.
Nov. 6	8:00 a.m.	Drawn off	22 deg. C.	24 hrs.	Total time of steeping 64 hrs.

was added and allowed to soak the barley for approximately 12 hours, when it was drawn off and set aside in a vessel until the entire quantity was drawn off. In this manner, as can be seen from the following table, 250 grs. of barley were steeped in 500 cc. of water at 20 degrees C. for 64 hours. At the end of this time the barley was sufficiently steeped, which was determined by a number of signs stated previously in this thesis. The volume of steep water was then measured and the analysis made immediately so as to prevent any slight changes in the composition due to fermentation. The steeped barley was put into a thermostat and water added to aid in its growth. The malt was turned over from time to time to equalize the growth in the kernels, and after about five days the malt was dried, and the analysis made. The analysis of the malt from the first trial with distilled and with tap-water was not made. The results of the steeping of the barley, and the analysis of the steep water follow. These results show that there is practically no difference in the amount of the different substances extracted by a hard or a soft water.

TABLE NUMBER 1.

Steeping of Barley in a) Tap Water and b) Distilled Water.

Date	Time	Amt.H2O	Temp. H2O	No. Hrs.	Remarks.
Nov. 3	4:00 p.m.	250 cc.	25 deg. C.	******	Sample Taken barley
Nov. 4	9:00 a.m.	300 cc.	23 deg. C.	16 hrs.	250 grs. Barley in each respectively.
Nov. 4	5:00 p.m.	300 cc.	22 deg. C.	8 hrs.	Vol. 420 & 430 cc
Nov. 5	9:00 a.m.	250 cc.	22 deg. C.	16 hrs.	[illegible]
Nov. 5	5:00 p.m.	Drawn off	20 deg. C.	24 hrs.	Total time of steeping 64 hrs.

Analyses of Steep Waters #1 and #2.

	Number 1		Number 2	
	"a"	"b"	"a"	"b"
Extract	.3173%	.3158%	.3125%	.3125%
Ash	.1432%	.1421%	.1388%	.1394%
Reducing Sugar	.0243%	.0249	.0122%	.0170%
Invertible "	.0191%	.0183%	.0217%	.0210%
Dextrin	.0295%	.0268%	.0233%	.0259%
Nitrogen	.009155%	.009155%	.009535%	.009535%
As Albumen	.05722%	.05722%	.05959%	.05959%
Specific Grav.	1.0014	1.0014	1.0013	1.0013
Amt. of H_2O	650 cc.		653 cc.	

In the second experiment the same waters were used with 300 grs. of barley and the total time of steeping was 73 hrs. More water was also added, the amount being 1300 cc and the temperature was considerably lower being 12 degrees C. Under this change in conditions a trifle more of the sugars went into solution and a little less of albuminous substances. The amount in either case is so small as to be of no consequence to the malster.

The tables containing the conditions of steeping and the analysis of the steep waters follows on the next page.

Analyses of Steam Waters at Elko #2.

Number :			
	A	B	C
Silica	.0756	.0768	.0768
Iron	.0005	.0001	.0001
Aluminum	.0000	.0000	.0000
Calcium	.0010	.0010	.0010
Magnesium	.0000	.0000	.0000
Sodium	.0660	.0660	.0660
Potassium	.0230	.0230	.0230
Lithium	.0000	.0000	.0000
Ammonia	.0000	.0000	.0000
Chloride	.0010	.0010	.0010
Fluoride	.0000	.0000	.0000
Sulfate	.0000	.0000	.0000
Bicarbonate	.0000	.0000	.0000
Carbonate	.0000	.0000	.0000
Boron	.0000	.0000	.0000
Arsenic	.0000	.0000	.0000
Hydrogen Sulfide	.0000	.0000	.0000
Total Solids	.1731	.1739	.1739
Specific Grav.	1.0019	1.0 ia	1.0019
Temp. of Flow	460 F.	460 F.	460 F.

In the second experiment the same waters were used but 500 gallons of boiling and the total time of standing was 72 hrs. Note again was also added, the amount being 1500 mg and the temperature was considerably lower being 12 degrees C. Under this change in conditions a little more of the oxygen went into solution and a little less of aluminum precipitated. The amount in either case is so small as to be of no consequence to the galaxy.

The tables containing the conditions of steeping and the analysis of the steep waters follows on the next page.

Number 1. Second Trial.

Steeping of Barley in #1 Tap and #2 Distilled.

Date 1903	Time	Amt. H_2O	Temp. H_2O	No. Hrs.	Remarks.
Nov. 25	9:00 a.m.	300cc	13 deg. C.	######	300 grs. Barley in each percolator.
Nov. 25	4:30 p.m.	250cc	13 deg. C.	7 1/2	Volume H_2O #1 is 1080cc
Nov. 26	8:00 a.m.	250cc	11 deg. C.	15 1/2	Volume H_2O #2 is 1074cc
Nov. 26	5:00 p.m.	250cc	13 deg. C.	9	Total time of steeping was 73 hrs.
Nov. 27	8:00 a.m.	250cc	10 deg. C.	15	
Nov. 28	10:00 a.m.	Drawn off	11 deg. C.	26	

Number 1. Second Trial.

Analyses of Steep Waters in #1 Tap and #2 Distilled.

	Number 1		Number 2	
	"a"	"b"	"a"	"b"
Extract	.2536%	.2542%	.2587%	.2580%
Ash	.1071%	.1069	.0907%	.0939%
Reducing Sugar	.06116%	.05104%	.04502%	.05001%
Invertible ''	.0181%	.0190%	.0228%	.01998%
Dextrin	.0729%	.0720%	.07158%	.7158%
Nitrogen	.008499%	.008499%	.008499%	.008499%
As Albumen	.05312%	.05312%	.05312%	.05312%
Sp. Gravity	1.0010	1.0010	1.0010	1.0010
Amt. of H_2O	1085cc		1074cc	

Number 1. Second Trial.

Steeping of Barley in #1 Jar and #2 Distilled.

Date 1904	Time	Mat. $MgCl_2$	Temp.	Mg Cl Ro.	Etc.	Remarks.
Mar. 28	9:00 a.m.	37000	18 deg.	C.	444444	300 grs. Barley in
Mar. 28	4:30 p.m.	38000	18 deg.	C.	7 1/2	[illegible]
Mar. 29	8:00 a.m.	38000	11 deg.	C.	18 1/2	Volume $MgCl_2$ in jar
Mar. 29	8:00 p.m.	38000	18 deg.	C.	9	Total time of steep
Mar. 30	8:00 a.m.	38000	18 deg.	C.	12	ing was 72 hrs.
Mar. 30	8:00 p.m.	Drops	11 deg.	C.	59	

Number 1. Second Trial.

Analyses of Steep Waters in #1 Jar and #2 Distilled.

	Number 1		Number 2	
	"A"	"B"	"A"	"B"
Extract	.05047	.05402	.05478	.05804
Ash	.1011	.1020	.09019	.09382
Reducing Sugar	.06(1)8	.0610+2	.0(illegible)28	.05(illegible)3
Insoluble	.0181	.0180	.0(illegible)84	.0190+4
Dextrin	.0798	.0798	.0(illegible)8	.1(illegible)8
Nitrogen	.00(illegible)1	.00(illegible)1	.00(illegible)97	.00(illegible)84
Ash Albumen	.0(illegible)8	.0(illegible)8	.0(illegible)2	.0(illegible)8
Sp. Gravity	1.0010	1.00(illegible)	1.0010	1.0010
Amt. of H $_2$ O	(illegible)		(illegible)	

In this trial the malt was completely grown and an analysis was made of it to see whether the steeping with waters of different hardness had any effect upon its composition. These malts were also washed and an analysis made of the worts. The malts were not sufficiently dried but for a matter of comparison in their composition this was no serious draw-back. The malt grown in the thermostat shows a growth of 80%, whereas the barley from which this malt was grown has a germinating power of 99%. This deficiency is due principally to practical conditions. 99% represents the theoretical growth of the malt, while practical conditions only produce an 80% growth. The analyses of the malts and worts from the distilled and tap water steeping are tabulated below:-

Analyses of Worts #1 and #2.

	Number 1		Number 2	
	"a"	"b"	"a"	"b"
Balling	7.316%	7.316%	7.195%	7.195%
Ash	.116%	.115%	.126%	.120%
Reducing Sugar	5.174%	5.174%	5.197%	5.197%
Dextrin	.171%	.192%	.297%	.269%
Nitrogen	.0889%	.0889%	.0878%	.0878%
As Albumen	.555%	.555%	.548%	.548%
S:NS--100:X	41.4	41.4	38.4	38.4
Albumen in X	7.58%	7.58%	7.61%	7.61%

In this trial the melt was completely green and an analysis was made of it in use showing the strength with mixtures of different sands but any effect upon its composition. These melts were also washed and an analysis made of the water. The melts were not evaporated to dryness but for a period of evaporation in their containers this was no serious draw-back. The melt grown in the laboratory above a growth of 90%, whereas the casing from which this melt was grown has a refractoriness power of 99%. This deficiency is due either to practical conditions. Not increasing the theoretical results of the melt, while practical conditions only produce an 80% growth. The analyses of the melts and sands from the distilled and tap water samples are tabulated below:-

Analyses of Melts #1 and #2.

	Number 1		Number 2	
	a	b	a	b
Melting	1.91%	1.81%	1.98%	1.98%
Ash	.12%	.12%	.10%	.10%
Reducing Power	5.11%	5.15%	5.13%	5.10%
Density	.11%	.10%	.20%	.20%
Nitrogen	.0004%	.0006%	.0012%	.0014%
As Oxygen	.02%	.03%	.04%	.04%
S.M.E.--100%	41.4	41.4	98.4	98.4
Silicon in %	1.62%	1.84%	1.91%	1.91%

Analyses of Malts #1 and #2.

	Number 1		Number 2	
	"a"	"b"	"a"	"b"
Moisture	10.70%	10.70%	11.85%	11.85%
Nitrogen	2.142%	2.142%	2.10%	2.10%
As Albumen	13.387%	13.387%	13.125%	13.125%
Wet Yield	63.93%	63.93%	62.88%	62.88%
Dry Yield	71.59%	73.59%	71.33%	71.33%
Bushel Weight	37 lbs.	37 lbs.	37 lbs.	37 lbs.
Full Grown	80%	80%	80%	80%
1/2---3/4	18%	18%	14%	14%
1/4---1/2	2%	2%	6%	6%
0---1/4	None	None	None	None
Glassy	''	''	''	''
Half Glassy	2%	2%	2%	2%
Bite	Mealy	Mealy	Mealy	Mealy
Raw Fibre	6.41%	6.29%	6.38%	6.45%
Ash	1.98%	1.97%	1.90	1.93%
Starch & Sugar	65.01%	64.89%	64.12%	64.22%

Analyses of Maize di ana 49.

	Number 1		Number 2	
	"A"	"B"	A	B
Moisture	13.70%	10.70%	13.88%	11.09%
Nitrogen	2.14%	2.14%	2.10%	2.10%
Ac Albumen	10.85%	10.85%	10.10%	9.10%
Wet Fiels	83.05%	83.05%	82.88%	82.88%
Dry Fiels	71.85%	72.85%	71.75%	71.75%
Bushel Weight	57 lbs.	57 lbs.	57 lbs.	57 lbs.
Full Grains	80%	80%	80%	80%
1/2- 3/4	15%	15%	14%	14%
1/4- 1/2	3%	3%	4%	4%
D- 1/4	None	None	None	None
Clean				
Mali Cleary	3%	3%	3%	3%
Bits	Many	Many	Many	Many
Raw Fiber	2.41%	2.30%	2.35%	2.10%
Ash	1.30%	1.30%	1.20	1.20%
Sugars & Sugar	10.01%	10.30%	10.10%	10.20%

Since there was practically no difference produced in the malt or wort, and the analyses of the steep-waters were pretty much the same whether a soft or a medium hard water was used for steeping, it was thought advisable to try several extremely hard waters. For this purpose the water had to be prepared artificially. To two liters of tap-water 500cc of a saturated solution of calcium sulphate was added, .2 of a gram of magnesium sulphate and 1/2 of a gram of sodium chloride. This furnished a water whose total solids were 3250 parts per million, and the loss on ignition was 285 parts per million.

The steeping of the barley was carried on as before, the total time of steeping and the temperature of the steep-water being the same, but the amount of water that was used to produce signs of sufficient steeping was less, 1100cc being required. In this case both percolators were filled with the prepared waters, the steeping and analysis being run in duplicate. The results as tabulated show a slight increase in the substances extracted. More reducing sugar was extracted due probably to some of the salts in solution and also to its alkalinity. The increase however is so small as to be disregarded and insignificant. A little more albuminous substances were also extracted, and this was also probably due to the salts in solution, because it is known that water containing sodium chloride in solution will dissolve out or extract more albuminous substances than a water which does not have sodium chloride in solution.

Since there was practically no difference produced in the malt at all, and the analyses of the steep-waters were pretty much the same whether a soft or a medium hard water was used for steeping, it was thought advisable to try several extremely hard waters. For this purpose the water had to be prepared artificially. To two liters of tap-water 300cc of a saturated solution of calcium sulphate was added, .2 of a gram of magnesium sulphate and 1/5 of a gram of sodium chloride. This furnished a water whose total solids were 2350 parts per million, and the loss on ignition was 390 parts per million.

The steeping of the barley was carried on as before, the total time of steeping and the temperature of the steep-water being the same, but the amount of water that was used to produce signs of sufficient steeping was less,-- 1100cc being required. In this case both percolators were filled with the prepared waters, the steeping and analyses being run in duplicate. The results as tabulated show a slight increase in the substances extracted. This reducing sugar was extracted due probably to some of the salts in solution and also to its alkalinity. The increase however is so small as to be disregarded and insignificant. A little more albuminous substances were also extracted, and this was also probably due to the salts in solution, because it is known that water containing sodium chloride in solution will dissolve out or extract more albuminous substances than a water which does not have sodium chloride in solution.

Steeping of Barley in Hardened Water #3 and Duplicate.

Date 1903	Time	Amt. H_2O	Temp. H_2O	No. Hrs.	Remarks.
Feb. 23	9:30 a.m.	300cc	15 deg.C.	######	300 grs. Barley used
Feb. 24	10:00 a.m.	300cc	12 deg.C.	24.5	Vol. H_2O #1 is 850cc
Feb. 24	6:00 p.m.	250cc	11 deg.C.	8	Vol. H_2O #2 is 828cc
Feb. 25	10:00 a.m.	250cc	11 deg.C.	16	Total time of steeping was 72.5 hrs.
Feb. 26	10:00 a.m.	Drawn off	12 deg.C.	24	

Analyses of Steep Waters #3 and Duplicate.

	Number 3		Duplicate.	
	"a"	"b"	"a"	"b"
Extract	.3672%	.3744%	.3812%	.3578%
Ash	.1925%	.2015%	.2150%	.2104%
Reducing Sugar	.1413%	.1442%	.1484%	.1433%
Invertible ''	.0380%	.0495%	.0444%	.0467%
Dextrin	.0725%	.0559%	.0563%	.0582%
Nitrogen	.01018%	.01018%	.00938%	.00938%
As Albumen	.06362%	.06362%	.05866%	.05866%
Spec. Gravity	1.0015	1.0015	1.0015	1.0014
Amt. of H_2O	850cc		828cc	

Water of Number 3

Total Solids 3250 parts per million.

Loss on ignition 285 parts per million.

Steeping of Barley in Reservoir Water #2 and Duplicate.

Date 1908	Time	Ref. Hyd. Temp.	Hyd. No. Tts.	Remarks.
Feb. 22	8:30 a.m.	60deg	18 deg.C.	Water
Feb. 24	10:00 a.m.	58deg	14 deg.C.	64:8
Feb. 24	4:00 p.m.	58deg	11 deg.C.	8
Feb. 25	10:00 a.m.	58deg	11 deg.C.	12
Feb. 27	10:00 a.m.	57deg	10 deg.C.	34

Total time of steep-
ing was 76.5 hrs.

Analyses of Steep Waters #2 and Duplicate.

	Number 2		Duplicate.	
	"a"	"b"	"a"	"b"
Nitrogen	.01018%	.01183%	.00988%	.00966%
As Albumen	.06375%	.07406%	.06187%	.06052%
Sper. Gravity	1.0014	1.0015	1.0014	1.0014
Amt. of H_2O	78ccs	83ccs		

Water of Number 2

Total Solids 3880 parts per million.

Lose on Ignition 328 parts per million.

The malt from this steep was thoroughly dried, and of course this had an effect on the yield of the malt, which however was practically the same as the yield of the malt produced by the previous steeping. The balling of the wort was higher and therefore they cannot be readily compared with the last worts, but the ratio of sugar to non-sugar should nevertheless be the same, and it is practically so in the four worts.

I had some difficulty in growing this malt, and because I could not keep a steady temperature the cut of the malt only shows a growth of 76%. I grew this malt in an open candy-pan covered with moistened filter paper, and I think under the temperature conditions a growth of 76% is remarkable.

Below follow the analyses of the worts and malts from the steeping with the prepared water, run in duplicate:-

Analyses of Wort #3 and Duplicate.

	Number 3		Duplicate	
	"a"	"b"	"a"	"b"
Balling	9.488%	9.488%	9.50%	9.50%
Extract	#10.67%	10.67%	10.64%	10.64%
Ash	.122%	.122%	.122%	.122%
Reducing Sugar	6.30%	6.57%	6.50%	6.40%
Dextrin	.270%	.270%	.205%	.305%
Nitrogen	.1034%	.1034%	.1003%	.1003%
As Albumen	.646%	.646%	.625%	.625%
S:NS--100:X	50.7	44.5	46.1	48.4
Albumen in X	6.80%	6.80%	6.58%	6.58%

Dried in air-bath 110 degrees C.

The malt from this sweep was inferiority dried, and of course this had an effect on the yield of the malt, which however was practically the same as the yield of the malt produced by the previous sweeps. The quality of the wort was higher and therefore that cannot be readily compared with the last wort, but the ratio of sugar to non-sugar should nevertheless be the same, and it is practically so in the four worts.

I had some difficulty in crushing this malt, and because I could not keep a steady temperature like that at the malt only above a growth of 70°. I grew this malt in an open pan covered with matted fibre paper, and I turned under the temperature conditions a growth of 70° is reasonable.

Below follow the analyses of the worts and malts from the steeping with the unsprayed water, run in duplicate:

Analyses of Malt as and Duplicate.

	Number 3		Duplicate	
	"A"	"B"	"A"	"B"
Boiling	0.0897	0.0888	0.092	0.091
Extract	410.277	10.277	10.442	10.443
Ash	.1901	.1888	.1904	.1904
Reducing Sugar	0.8%	0.871	0.8%	0.8%
Dextrin	.2708	.2703	.2686	.2698
Nitrogen	.1001	.1004	.1003	.1038
As Albumen	.625	.627	.6887	.6487
S.G.--100:1	80.7	84.8	41.1	43.4
Albumen in 1	1.801	1.8:1	1.881	1.881

* Dries in air dry 110 degrees C.

Analyses of Malt #3 and Duplicate.

	Number 3		Duplicate	
	"a"	"b"	"a"	"b"
Moisture	5.43%	5.50%	5.38%	5.50%
Nitrogen	2.232%	2.232?	2.232%	2.232%
As Albumen	13.95%	13.95%	13.95%	13.95%
Wet Yield	63.57	63.57	63.55	63.55
Dry Yield	67.27	67.27	67.27	67.27
Bushel Weight	37 lbs.	37 lbs.	37 lbs.	37 lbs.
Full Grown	74%	72%	72%	76%
1/2---3/4	20%	22%	22%	18%
1/4---1/2	4%	4%	4%	4%
0---1/4	2%	2%	2%	2%
Glassy	None	None	None	None
Half Glassy	2%	2%	2%	2%
Bite	Mealy	Mealy	Mealy	Mealy
Raw Fibre	6.534%	6.472%	6.513%	6.392%
Ash	2.36%	2.00%	1.94%	1.98%
Starch & Sugar	69.14%	69.56%	69.70%	69.66%

Analyses of Nuts #2 and Duplicate.

	Number 2		Duplicate	
	"a"	"b"	"a"	"b"
Moisture	4.45%	5.00%	5.28%	5.10%
Nitrogen	2.29%	2.28%	2.26%	2.25%
As Albumen	13.95%	13.96%	13.94%	13.95%
Wet Yield	42.3?	42.3?	42.3?	42.3?
Dry Yield	41.3?	41.3?	41.3?	41.3?
Dumped Weight	21 lbs.	21 lbs.	21 lbs.	21 lbs.
Full Grown	140	139	139	140
1/2-----3/4	304	305	304	181
1/4-----1/2	40	40	41	41
0-----1/4	37	38	34	37
Blasty	Some	None	Some	None
Half Blasty	37	37	38	38
Blue	Nealy	Nealy	Nealy	Nealy
Few Tips	4.8548	4.4758	4.8138	5.2858
Ash	2.37%	2.30%	1.84%	1.98%
Starch & Sugar	49.14%	49.31%	50.77%	50.98%

As the use of this specially prepared water in steeping showed no appreciable difference in the amount and substances extracted, two other waters were prepared as follows:- For water #4 to four liters of distilled water, 10 grams of crystallized magnesium sulphate, 10 grams of finely pulverized sulphate of lime, 2 grams of sodium nitrate, and 25 grams of dry sodium carbonate were added and the mixture heated. Carbonic acid from a generator was then run in for several days to bring as much into solution as possible. The water was then filtered and kept in a cool place ready for steeping. Water #5 was prepared in the following manner:- In two liters of distilled water 10 grams of pure precipitated carbonate of lime was suspended, and 10 grams of magnesium carbonate was added and then carbonic acid was run in until all the mineral matters were dissolved. I then added 5 grams of dry sodium carbonate. The mineral matters in these waters would not go into solution completely and after running in carbonic acid for several days the waters were filtered. Upon analysis water #4 showed total solids of 8423 parts per million and water #5 showed 5795 parts per million.

The barley was steeped in these exceedingly hard waters for 71 hours at a little higher temperature than usual due to the warm weather.

The analyses of the steep waters does not vary much from any of the previous analyses, only in that less albuminous substances were extracted, and this is probably explained by the fact that these waters contained absolutely no sodium chloride or any other salt

which increases the solubility of albuminous substances. The largets difference in any of the analyses was one tenth of one per cent, and I think this is remarkable because the amounts to be weighed were always so small and an error of one milligram would make considerable difference in the final result of an analysis.

The malt and wort are practically the same as that obtained from water #3, and the variations present are allowable by the analyst. The malt was not grown so well as from water #3. The moisture is a little higher and as a consequence the yield is a little lower, but this deficiency is often obtained in an analysis of exactly the same malt.

On the whole my experiment shows that it makes no practical difference to the malster whether he uses a soft or a hard water during steeping. It is to be admitted however that waters of certain compositions are preferable, because the presence of certain salts increase the dissolving power of a water towards substances which the malster does not want dissolved and hence are injurious to the final product.

The following tables show the results of steep waters #4 and #5 and the analyses of malts and worts produced from these waters:-

SEE PAGES 18, 19 AND 20.

Steeping of Barley in Specially Prepared Water #4 and #5.

Date 1903	Time	Amt. H_2O	Temp. H_2O	No. Hrs.	Remarks.
Apr. 11	11:00 a.m.	300cc	20 deg.C.	#######	300 grs. Barley in each percolator. Vol. #4 is 1148cc. Vol. #5 is 1136cc. Total time of steeping was 71 hrs.
Apr. 12	9:00 a.m.	300cc	20 deg.C.	22	
Apr. 12	6:00 p.m.	300cc	20 deg.C.	9	
Apr. 13	10:00 a.m.	250cc	18 deg.C.	16	
Apr. 13	5:30 p.m.	250cc	15 deg.C.	7.5	
Apr. 14	10:00 a.m.	Drawn off	20 deg.C.	16	

Total solids #4 8423 parts per million

Total solids #5 5795 parts per million.

Analyses of Steep Water #4 and #5

	Number 4		Number 5	
	"a"	"b"	"a"	"b"
Extract	.4157%	.4131%	.4061%	.4101%
Ash	.1642%	.1679%	.1597%	.1521%
Reducing Sugar	.1062%	.1062%	.1500%	.1230%
Invertible ''	.0787%	.0828%	.1175%	.1169%
Dextrin	.040%	.040%	.1384%	.1233%
Nitrogen	.00471%	.00471%	.00551%	.00551%
As Albumen	.02943%	.02943%	.03443%	.03443%
Spec. Gravity	1.0017	1.0017	1.0016	1.0016
Vol. of H_2O	1148cc		1136cc	

Analyses of Malts #4 and #5.

	Number 4		Number 5	
	"a"	"b"	"a"	"b"
Moisture	7.35%	7.36%	7.27%	7.25%
Nitrogen	2.155%	2.155%	2.223%	2.223%
As Albumen	13.46%	13.46%	13.89%	13.89%
Wet Yield	61.17%	61.17%	61.17%	61.17%
Dry Yield	66.03	66.03	66.03	66.03
Bushel Weight	37 lbs.	37 lbs.	37 lbs.	37 lbs.
Full Grown	70%	68%	72%	70%
1/2---3/4	18%	18%	22%	16%
1/4---1/2	10%	12%	4%	12%
0---1/4	2%	2%	2%	2%
Glassy	None	None	None	None
Half Glassy	2%	2%	2%	2%
Bite	Mealy	Mealy	Mealy	Mealy
Ash	2.30%	2.33%	2.24%	2.29%
Raw Fibre	6.35%	6.294%	6.534%	6.72%
Starch & Sugar	68.04%	68.06%	68.57%	64.35%

Analyses of Worts #4 and #5

	Number 4		Number 5	
	"a"	"b"	"a"	"b"
Balling	9.15%	9.15%	9.15%	9.15%
Spec. Gravity	1.0369	1.0369	1.0369	1.0369
Reducing Sugar	6.25%	6.32%	6.30%	6.30%
Dextrin	.232%	.232%	.275%	.303%
Nitrogen	.1031%	.1031%	.100%	.100%
As Albumen	.633%	.633%	.625%	.625%
S:NS--100:X	46.2	44.8	45.2	45.2
Albumen in X	6.91%	6.91%	6.83%	6.83%

###END###